WARFIGHTER'S INFORMATION PACKAGING (WIP)

ISX Corporation

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AIR FORCE RESEARCH LABORATORY
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13. ABSTRACT *(Maximum 200 Words)*

The Warfighter's Information Packaging effort developed a suite of distributed components to deliver packages of information to the warfighter. These packages are designed to deliver the most relevant, up-to-date information to warfighters at all echelons by populating report templates with information from all available sources. Subject matter experts can develop effective templates ahead of time. Those templates are then available to all personnel, regardless of their level of expertise. A wide range of sources are made available by the application of information integration techniques in the form of a mediation service. The final effort focused on the development of a template for use by strike mission planners and a mission-planning expert system. The system developed is capable of reasoning about available supply and refueling missions, aircraft ranges, and distances to targets, in order to present a focused set of options to the mission planner.

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Preface and Acknowledgments

This report is the final report summarizing the results of the effort expended by the ISX team in support of Contract F30602-98-C-0001. For additional information, contact Justin Donnelly, ISX Corporation, at jdonnelly@isx.com.

1. *Summary*

ISX Corporation developed a suite of distributed components whose purpose was to facilitate the delivery of information to the warfighter from a wide variety of sources. The following key components have been delivered as a result:

- Product Packaging. A suite of components and tools that apply templates designed by subject matter experts to available information in order to deliver an information product tailored to the needs of a warfighter.
- Mediation Service. Allows a single point of access to a wide variety of diverse, heterogeneous data sources.
- Information Package Templates. Based on the input of subject matter experts, several templates were designed.
- Strike Mission Planner Expert System. Given information about the friendly order of battle and base and target locations, this system provides an appropriate set of options for a strike planner to consider.

Completion of these components resulted in successful installation and demonstration of the system at AFRL Information Directorate at Rome, NY.

2. *Introduction*

The warfighter requires delivery of targeted, timely information in order to fulfill the duties of his role. While the wide variety of data sources available ensures that all the information required does exist, acquiring the relevant pieces of information from the enormous amount of data is a challenge. Furthermore, the complexity of most data sources precludes the facile retrieval of the necessary data.

The Warfighter's Information Packaging system addresses this challenge with two key strategies. It provides tools to create and apply *Information Package Templates*. Using these templates, subject matter experts and data source experts can develop the structure of key reports and views of the battlespace that can be reused over and over again by those without expert knowledge of the data sources. The power of information package templates is enhanced by the application of information integration techniques that provide seamless access to multiple, distributed, heterogeneous data sources. The software that implements these techniques, known as the mediation service, simplifies the development of new templates by providing a single view of the data sources available.

In its final phase, the effectiveness of the use of an expert system in the process of planning strike missions was explored. The expert system was accessed via the mediation service as part of an information package template. Not only did this demonstrate the usefulness of the expert system itself, but it also validated the effectiveness of the WIP components as well.

3. *Purpose*

The goal of this project was to develop working software components in order to provide a functional system and to transfer techniques developed at the university level to working military applications. The results of the effort at each stage were demonstrated to a mix of military users and technology developers, while the final product was delivered to and installed at the AFRL Information Directorate at Rome, NY for further demonstration and evaluation.

4. *Benefits*

The Warfighter's Information Packaging system provides a number of benefits in terms of the timely delivery of information to warfighters in any role:

- Reports and views *tailored* to their needs are available due to the fact that templates have been defined in advance in order to capture the best available knowledge of the many available data sources and the expertise regarding the process that the warfighter in any particular role will be following.
- Warfighters will not require expert knowledge of the data sources available, nor the access paths required to reach them.
- Tools for easily developing new templates are available.
- Access to new data sources is readily achieved with a small amount of development effort in the form of creating a *wrapper* that is used by the mediation service to access the source.
- The time required to access data sources is reduced by use of package templates.

All these benefits are available from a common, integrated suite of tools and components.

5. *Methods, Assumptions, and Procedures*

The WIP program operated on the principle that the rapid development and integration of new software components followed by evaluation and feedback from customers and end users would produce the best results. This process was repeated several times, resulting in an evolving path of development that allowed the exploration of new ideas.

6. *Results*

The goal of the WIP program was to produce working, functional software components. The most significant of these are described below.

6.1 *Product Packaging*

Product packaging [Zev 99] is, in fact, a suite of components and tools responsible for the entire process of designing, applying, storing, and rendering information package templates.

The information-packaging concept is that the form of an information product or report can be separated from the information itself. The template for the form of an information product can therefore be created in advance, by experts in both the process that the consumer of the information will be undergoing and experts in the data sources available.
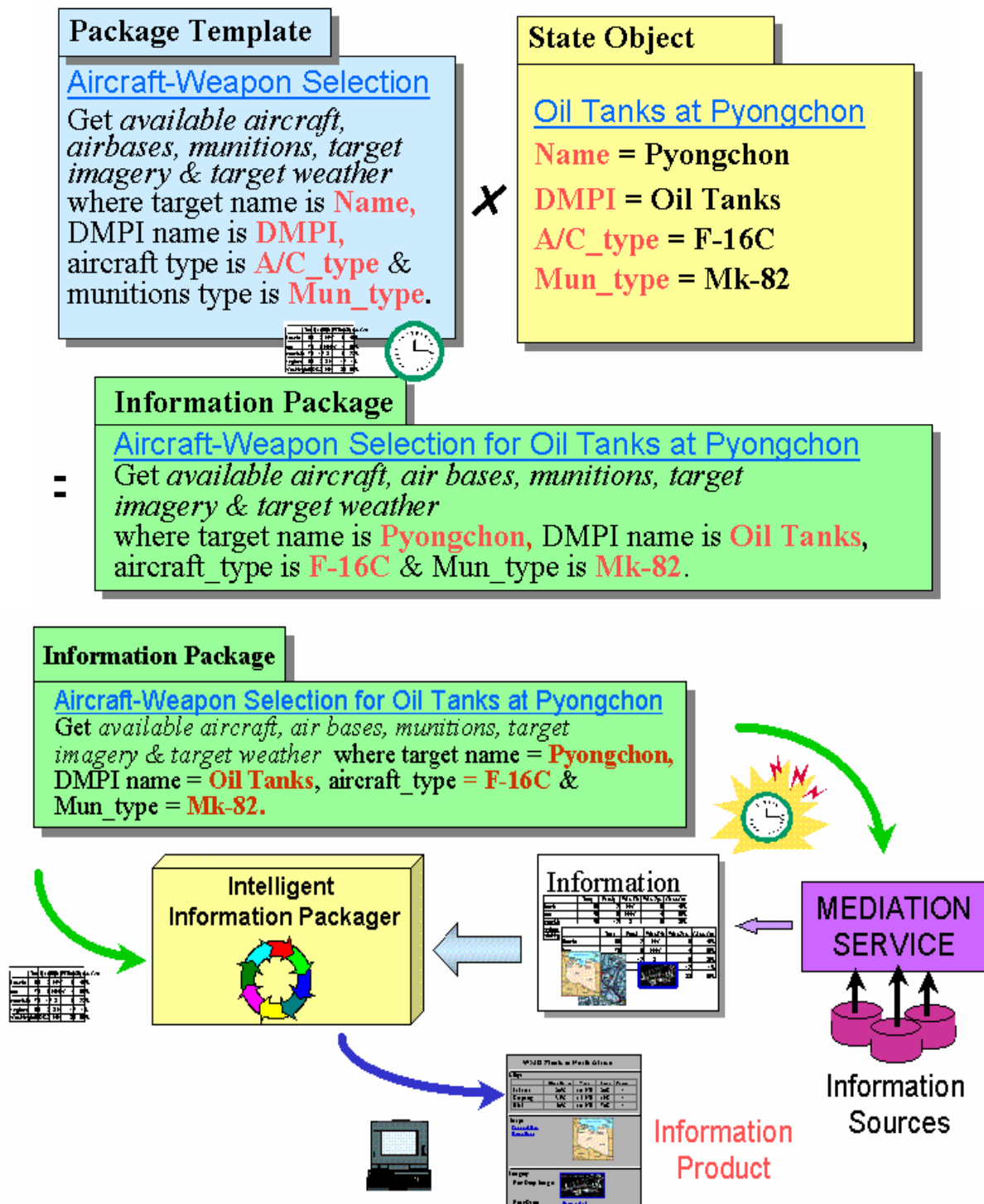
Figure 1. Information Packaging Process

The process of applying an information package template to the available information (illustrated in Figure 1. Information Packaging Process) is as follows. The product packager components retrieve the information package template and combine it with the information consumer's *state object*, which represents their current situation, including who they are, where they are operating, what their role is, and the details of their mission. The most significant component of the information package template is a set of parameterized data source queries. The result of the combination is called the information package, which now contains fleshed out queries specific to the information consumer's situation. The next step is to submit the queries to the mediation service, which in turn submits them to the data sources it is aware of, decomposing and rewriting the queries as necessary. The results of the queries are collected by the mediation service and returned for inclusion in the end result of the entire process, called the information product. The final step is the rendering of the information product in a form suitable for the device used by the information consumer. The current options are HTML, low-band HTML (images are available via links instead of being included inline), and text, allowing an appropriate form for a variety of devices, from computer workstations to palm-sized organizers.

The architecture [Leherer 98] of the components involved in this process utilizes the CORBA (Common Object Request Broker Architecture) standard for communication. In other words, they expose their functions via interfaces defined in IDL (Interface Definition Language), and communicate with each other by calling those functions via the IIOP (Internet Inter-Orb Protocol) communication standard. The ORB (Object Request Broker) used was the Java IDL service included with implementations of the Java 2 development kit. All development was done in the Java language, which provides secure, stable run-time environments on a variety of platforms and in multiple tiers of development (applets for the client tier, JSP for middle-tier delivery of information to applets and web clients, and the standard run time for all server-side components).

The following sections provide more detailed information on each of the components and tools that implement the process described above.

6.1.1 Product Packager

The product packager is the component responsible for orchestrating the entire process of retrieving templates and state objects, obtaining results from the mediation service, building the information product, and rendering the product into text or HTML.

6.1.2 Mediation Service

The mediation service is described in its own section, 6.2.

6.1.3 Data Server

Also known as the *OEM Server*, the data server is responsible for the storage and retrieval of documents and fragments of data represented in the OEM (Object Exchange Model) language [Goldman 97]. OEM, designed to be a flexible, general-purpose data-representation language, is used to represent all of the information in the product packaging system, including information package

templates, state objects, the results of mediation service queries, and the information products. The data server is capable of operating in two modes. The first uses an object database. If an ObjectStore installation is available, the data server will store all information in ObjectStore in order to achieve a high degree of performance, reliability, and scalability. If ObjectStore is unavailable, the local file system is used to provide flexibility in a variety of deployment situations (including distributable demonstrations).

6.1.4 Package Rendering

Package rendering is accomplished with a custom designed library capable of translating OEM documents into HTML or plain text. This library is utilized by a set of JSP pages responsible for accepting requests from web browsers for information products.

6.1.5 Package Editor

The package editor is responsible for most of the user interaction with the WIP system, including the authoring of information package templates, the population of state objects, the design of the parameterized queries included in templates, and the application of templates to create an information product. The package editor is a Java application designed to be deployed as an applet, so that it can be accessed alongside the browser-based retrieval of rendered information products.

6.2 Mediation Service

The mediation service facilitates access to multiple, heterogeneous data sources. This is accomplished by analyzing queries and forwarding them to appropriate data sources. The queries accepted and passed on are written in the OQL [Cattel 94]language. The data sources must be accompanied by *wrappers* designed to accept the OQL queries. The wrapper is responsible for advertising the data schema of the source, translating the OQL queries into the query mechanism of the source, and then translating the results of a query into OEM, the common data representation language of the mediation service. The mediation service is, in turn, responsible for collecting all of the responses, aggregating the results, and returning them to the process which originally submitted the query.

In addition, the mediation service has a limited ability to re-write queries based on the data schema advertised by each data source wrapper. For example, if a query asks for data items a, b, and c, the mediator may rewrite a query to ask for simply b and c if that is the limit of the scope of a data source's schema.

Finally, the mediation service has a special ability to provide time-based subscription to data sources. When a query is received, if a client so desires, the latest results of submitting the query to the current set of available data sources will be delivered to the client. Making use of this ability, the product packaging system can provide up-to-date results in information products. Unfortunately, due to scheduling and budget constraints, all of the WIP components were not updated to make use of this ability, and it was never demonstrated.

6.3 Information Package Templates

In order to demonstrate the capabilities of the WIP system, several information package templates were developed. The application of these templates in various hypothetical situations formed the basis of the

several successful demonstrations of WIP. The first two were straightforward examples of the form of the information that might be presented to a pilot prior to embarking on a strike mission and to an intelligence analyst examining the production of weapons of mass destruction in hostile countries.

The final example developed was the result of a concerted effort to acquire an understanding of the process that strike mission planners undergo. The process was then implemented in an expert system described in section 6.4 Strike Mission Planner Expert System. The form of the results of the process was then carefully described in an information package template that could then be applied to a particular planner's situation. The results of building an information product and rendering it as HTML using this template are shown in Figure 2. Strike Mission Planning Information Product.

Figure 2. Strike Mission Planning Information Product

6.4 Strike Mission Planner Expert System

The final effort of the WIP program, dubbed *Intelligent Information Packaging (IIP)*, involved the development of an expert (or rule-based) system designed to model the process undertaken by a strike mission planner. Extensive analysis was performed in order to produce the model, which is illustrated in

Figure 3. Strike Mission Planning Process. The expert system was produced using a toolkit called JESS (Java Expert System Shell), developed at Sandia National Laboratories in Livermore, CA. The expert system makes use of axioms and rules to produce original facts about the system being modeled. In the case of the mission planning process, the axioms were data about the battlespace, including friendly order of battle, the set of refueling missions planned including their tracks, and the location of friendly airbases and the target of interest. The rules, on the other hand, covered the spatial relationships of locations described by latitude and longitude, the logistical requirements of strike missions including external fuel tanks, munitions, external tanks, and countermeasures, and the rules of engagement for the theater of interest. The facts produced by the system were sets of possible flight configurations capable of accomplishing the specified mission. These are shown in the "Aircraft Resources" table in Fig. 2.
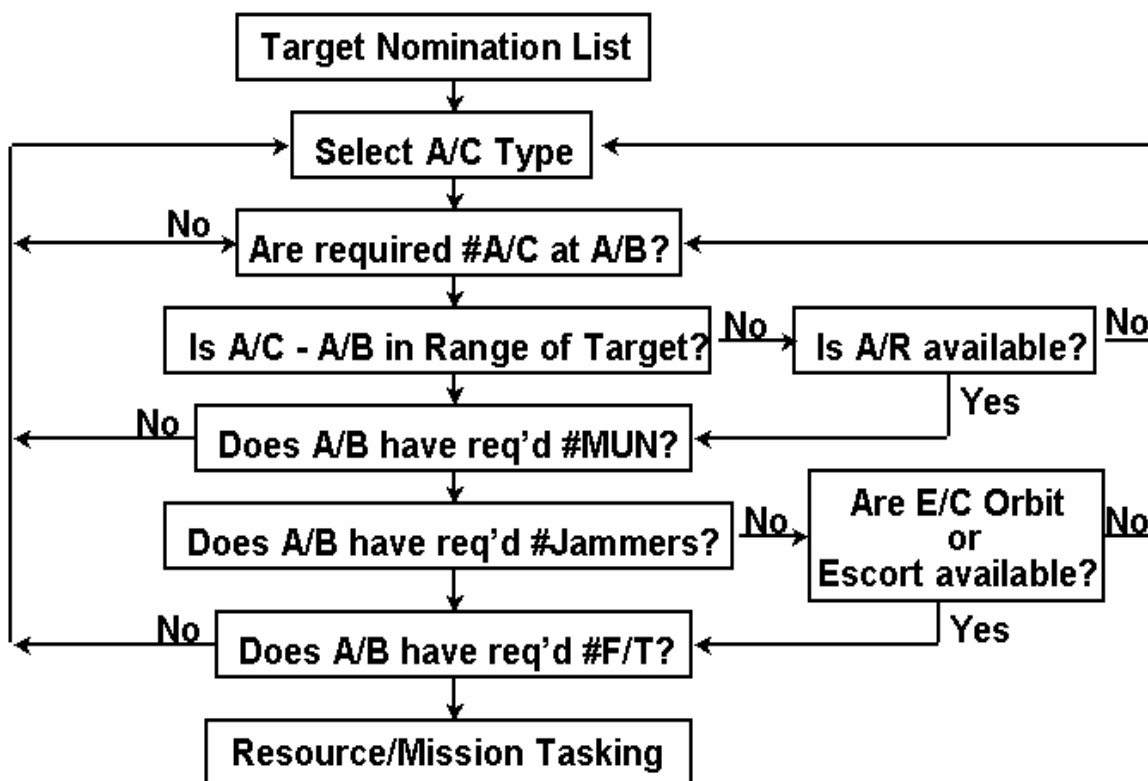

Figure 3. Strike Mission Planning Process

With this expert system available as a mediation service data source, and delivered to a mission planner as part of an information product, the planner is relieved of the tedious and time-consuming process of discovering potential flight configurations by trial and error. Instead, the planner is free to concentrate on the more critical decisions regarding the effectiveness of the various flight options, as well as balancing the impact of the chosen flight on overall air mission objective.

7. Conclusions

The WIP program demonstrated the effectiveness of the information packaging concept and the value of information integration (mediation) techniques. Furthermore, these two approaches fit nicely together to produce a system capable of producing relevant, high value reports delivered to the warfighter in a timely fashion. The final effort, Intelligent Information Packaging, was not only successful in its own right at producing valuable information products for strike mission planners, but additionally validated the component-based (in other words, modular) design of the WIP system and the facility with which new sources can be added to the mediation service.

8. Recommendations

The WIP system is a set of working components capable of limited deployment in an operational environment in order to develop additional feedback on the function and design of the system as a whole. Such a deployment, along with the funding necessary to incorporate changes based on user feedback, additional hardening of the components, and the development of new features is recommended. In particular, a number of improvements are currently envisioned:

- Replace OEM with XML. The OEM language, invented by the Stanford Database Group, preceded XML as a textual, free form description of data. Capable as it is, replacing the use of OEM with that of XML would provide a host of benefits. The popularity of the XML standard has resulted in the development of a wide array of tools, techniques, and other standardized languages, all of which could be taken advantage of by the WIP components as well as by users of the WIP system.
- Replace current rendering with XSL-T. The current information product-rendering library was state of the art when developed several years ago. However, with the advent of XML, a superior technique has emerged. XSL-T is a language that allows the declarative description of processes for translating XML to other forms. If OEM was replaced by XML as the data description language used by the WIP components, XSL-T could be used to render the information products as HTML and text in a much more flexible manner than is currently possible. Furthermore, new renditions (such as WML for display on hand-held wireless devices) could be added much more easily than is currently possible.
- Create additional bindings. Control of the WIP system is currently available to any software components that can communicate using IIOP, the communications protocol used by CORBA components. The addition of new interfaces capable of responding to requests from other kinds of components, such as RMI components, or agent-based systems, such as the DARPA CoABS Grid or implementations of FIPA or KQML, would allow deployment and control of the WIP system in the greatest possible number of environments.

9. List of Symbols, Abbreviations, and Acronyms

AFRL   Air Force Research Laboratory
CoABS   Control of Agent-Based Systems

CORBA	Common Object Request Broker Architecture
DARPA	Defense Advanced Research Projects Agency
DMPI	Direct Mean Point of Impact
FIPA	Foundation for Intelligent Physical Agents
HTML	Hyper Text Markup Language
IDL	Interface Definition Language
IIOP	Internet Inter-Orb Protocol
IIP	Intelligent Information Packaging
JESS	Java Expert System Shell
JSP	Java Server Pages
KQML	Knowledge Query and Manipulation Language
OEM	Object Exchange Model
OQL	Object Query Language
ORB	Object Request Broker
RMI	Remote Method Invocation
WIP	Warfighter's Information Packaging
XML	Extended Markup Language
XSL-T	Extensible Stylesheet Language Transformations

10. References

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